राष्ट्रीय प्रौद्योगिकी संस्थान मेघालय
NATIONAL INSTITUTE OF TECHNOLOGY MEGHALAYA
Bijni Complex, Laitumkhrah, Shillong – 793 003

MECHANICAL ENGINEERING DEPARTMENT

Syllabus for Written Test to Ph. D Programme, August 2015.

Group A: (30 Marks: MCQ)

1) Linear Algebra

Matrix algebra, Systems of linear equations, Eigenvalues and eigenvectors, invariant space.

2) Statics and Dynamics

Force and moment vectors, resultants, Principles of statics and free-body diagrams, Applications to simple trusses, frames, and machines, Properties of areas, second moments, Internal forces in beams, Laws of friction. Principles of particle dynamics, Mechanical systems and rigid-body dynamics, Kinematics and dynamics of plane systems, Energy and momentum of 2-D bodies and systems.

3) Differential equations

First order equations (linear and nonlinear), Higher order linear differential equations with constant coefficients, Cauchy's and Euler's equations, Initial and boundary value problems, Laplace transforms, Solutions of one dimensional heat and wave equations and Laplace equation.

4) Logical Reasoning, Data Analysis & Interpretation and Verbal Ability

Number Sequence Completion; Pattern Completion; Sets based on grouping and patterns; Seating Arrangement problems; Circular Arrangements; Relational problems; Selection and Conditionals; Mapping and best routes; Miscellaneous sets consisting of formal logic, testing, sports events and other critical reasoning, Data Analysis, Data Interpretation, Data Sufficiency, Reading Comprehension, Verbal Logic, Vocabulary, Grammar Correction.

Group B: (40 Marks: MCQ)

This section will cover fundamentals from B. Tech Syllabus in Mechanical Engineering.

Group C: (30 Marks: Descriptive)

Candidate is required to answer one of the groups. However, his/her selection may not be limited to that specialization only.

Fluid and Thermal

Fluid Mechanics: Fluid properties; fluid statics, manometry, buoyancy; control-volume analysisof mass, momentum and energy; fluid acceleration; differential equations of

continuity andmomentum; Bernoulli's equation; viscous flow of incompressible fluids; boundary layer;elementary turbulent flow; flow through pipes, head losses in pipes, bends etc.

Heat-Transfer: Modes of heat transfer; one dimensional heat conduction, resistance concept,electrical analogy, unsteady heat conduction, fins; dimensionless parameters in free and forcedconvective heat transfer, various correlations for heat transfer in flow over flat plates and throughpipes; thermal boundary layer; effect of turbulence; radiative heat transfer, black and greysurfaces, shape factors, network analysis; heat exchanger performance, LMTD and NTUmethods.

Thermodynamics: Zeroth, First and Second laws of thermodynamics; thermodynamic systemand processes; Carnot cycle.Irreversibility and availability; behaviour of ideal and real gases,properties of pure substances, calculation of work and heat in ideal processes; analysis ofthermodynamic cycles related to energy conversion.

Applied Fluid and Thermal: *Power Engineering*- Steam Tables, Rankine, Brayton cycles with regeneration andreheat. *I.C. Engines*: air-standard Otto, Diesel cycles. *Refrigeration and air-conditioning*- Vapour refrigeration cycle, heat pumps, gas refrigeration, Reverse Brayton cycle; moist air:psychrometric chart, basic psychrometric processes. *Turbomachinery*– Peltonwheel, Francis and Kaplan turbines, impulse and reaction principles, velocity diagrams, Eulers equation for turbine, draft tube, surge tank, water hammer, Thomas cavitation factor, NPSH, hydro turbine governing system, Hydraulic pump, rotodynamic pump, positive displacement pump, hydraulic motor, aerofoil theory.

Computational Fluid Dynamics: Definition and Importance of CFD, Mathematical classification of PDEs – parabolic, elliptic and hyperbolic equations, role of characteristics, essential and natural boundary conditions, Principles of discretization – preprocessing, solution and post processing, types of boundary conditions, conservativeness, boundedness, transportiveness, overview of finite difference, finite element and finite volume methods, Stability analysis of parabolic and hyperbolic equation – FTCS, CTCS, FTFS, FTBS, CTCS schemes, stream-function vorticity, staggered grid and collocated grid. SIMPLE, SIMPLEC and SIMPLER algorithms.

Applied Mechanics, Design and Manufacturing

Engineering Mechanics: Free body diagrams and equilibrium; trusses and frames; virtual work;kinematics and dynamics of particles and of rigid bodies in plane motion, including impulse andmomentum (linear and angular) and energy formulations; impact.

Strength of Materials: Stress and strain, stress-strain relationship and elastic constants, Mohr'scircle for plane stress and plane strain, thin cylinders; shear force and bending moment diagrams;bending and shear stresses; deflection of beams; torsion of circular shafts; Euler's theory ofcolumns; strain energy methods; thermal stresses.

Theory of Machines: Displacement, velocity and acceleration analysis of plane mechanisms;dynamic analysis of slider-crank mechanism; gear trains; flywheels.

Vibrations: Free and forced vibration of single degree of freedom systems; effect of damping;vibration isolation; resonance, critical speeds of shafts.

Design: Design for static and dynamic loading; failure theories; fatigue strength and the S-Ndiagram; *principles* of the design of machine elements such as bolted, riveted and welded joints,shafts, spur gears, rolling and sliding contact bearings, brakes and clutches.

Engineering Materials: Structure and properties of engineering materials, heat treatment, stressstrain diagrams for engineering materials.

Manufacturing Science and Technology: *Metal Casting***-** Design of patterns, moulds and cores; solidification and cooling; riser and gatingdesign, design considerations.*Forming* **-** Plastic deformation and yield criteria; fundamentals of hot and cold workingprocesses; load estimation for bulk (forging, rolling, extrusion, drawing) and sheet (shearing,deep drawing, bending) metal forming processes; principles of powder metallurgy.*Joining* **-** Physics of welding, brazing and soldering; adhesive bonding; design considerations in welding. *Machining and Machine Tool Operations* **-** Mechanics of machining, single and multi-pointcutting tools, tool geometry and materials, tool life and wear; economics of machining;principles of non-traditional machining processes; principles of work holding, principles ofdesign of jigs and fixtures. *Computer Integrated Manufacturing* **-** Basic concepts of CAD/CAM and their integrationtools.

Metrology and Inspection: Limits, fits and tolerances; linear and angular measurements;comparators; gauge design; interferometry; form and finish measurement; alignment and testingmethods; tolerance analysis in manufacturing and assembly.